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ROLE OF LIVING MATTER IN CARBONATE FORMATION

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16. Abstract

Blue-green algae in the waters of the Sukok and Parkent river basins of the western Tien-Shan absorb calcium from the river waters (57-156 mg/l). When the rivers fall and the algae are exposed to direct sunlight, chemical and microscopic analysis demonstrates formation of crystalline calcium carbonate, increasing from an initial 5-7% to 28% and more in a day, as the algae dry out and die. Similarities between the thermograms characterizing the stages of carbonate formation during drying-out of the algae and the carbonate "beards" on the lower surfaces of alluvial-colluvial detritus and soils in the area indicate a genetic similarity. Thus carbonate formation on river rocks, detritus and in the soils is attributed to the activities of the blue-green algae and microorganisms, and not to carbonate precipitation from water solutions.

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The migration of calcium conforms to the principles of vertical and horizontal zonation, dependent on bioclimatic factors [8]. In the mountains and foothills of central Asia, detritus is encountered at a depth of 10-200 cm in the soil layer, the lower surface of which is covered with a crust of carbonates, up to 0.5 cm thick. In the Caucasus, carbonate growth on the lower sides of rocks reaches 20 cm [3]. Carbonate crusts (or "beards") have a well expressed colliform structure and crypto-crystalline microstructure in thin section. Their composition includes silicon dioxide (up to 2%), which usually is not encountered in carbonate new growths. /32*

In early works, B.B. Polynov [5] distinguished chemogenic and biogenic carbonate origin. He gave the preference to the first, considering chemogenic concretions, crusts, films and uniformly scattered mealy carbonate material in the soil. However, in works of the following years, B.B. Polynov [6, 7] acknowledges that "... the initial appearance of calcium carbonate in the products of weathering of primary rocks completely owes its origin to the activities of organisms." On the basis of these ideas, we examine the genesis of carbonate matter in alluvial-colluvial and eluvial supergenesis zones of central Asia.

A knowledge of the nature of carbonate "beards" assists in explaining the features of genesis of carbonate matter, which appears in the most diverse forms: lime nodules, pulverized matter, solid horizons and others.

The lower surfaces of detritus serve as a screen, retarding the abundantly evaporating moisture. As a result, conditions

*Numbers in the margin indicate pagination in the foreign text.

are created which are favorable for settlement of microorganisms on the lower surfaces of the detritus. The deposition of lime is connected with the activities of microorganisms. N.A. Krasil'nikov [4] demonstrated that a thin deposit of $CaCO_3$ appeared on the detritus in a 10 month test. Carbonate formation took place in a definite sequence: amorphous $CaCO_3$ appears initially in the bacterial slime, in the form of round bodies of various sizes, and later it is transformed into dense crystalline conglomerates, sometimes forming large conglomerations. The leading role in carbonate formation most likely belongs to not only bacteria, as many microbiologists consider, but to algae. The high selective ability of blue-green algae for calcium is well-known, for example. No less important is the fact that, of all plant organisms (bacteria, bryophytes, grasses and others), containing no more than 10% salt, algae are the most enriched (20-30% of the weight of dry substance) in mineral compounds [1].

In the opinion of M.A. Glazovskiy [2], green and blue-green algae play the primary part in extraction of calcium carbonate from rocks and solutions, as well as in formation of various forms of calcite. /33

During observations in the basins of the Sukok and Parkent rivers of the western Tien-Shan, it was determined that blue-green algae settle on the rocks under water in the summer and fall, when the water in the river reaches temperatures of 12-17°. Up to 300 g of matter (converted to absolute dry matter) occurs per 1 m^2 of river bed. Together with bryophytes, for distances of many kilometers, they carry out the part of filters, removing the chemical elements necessary to them from the river water. They absorb particularly large amounts of calcium:[1] 57-156 mg/l, in place of 24-51 in river water and 5-8 mg/l in atmospheric deposits (Table).

[1]From data of complete chemical analysis. Recalculations show that calcium is bound to the hydrocarbonate and sulfite anions.

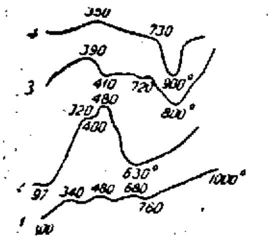
TABLE 8. CHEMICAL COMPOSITION OF WATER, TRANSFORMED BY ORGANIC MATTER (WESTERN TIEN-SHAN, SUKOK AND PARKENT RIVER BASINS), mg/l.

Date	Sample	Reactive CO_3	Residue Density	NCO_3	Cl	SO_4	Ca	Mg	Na+K	pH
				Sukok River						
26 Feb. 1968	Water squeezed out of bryophytes growing on granite rock	48.3	324	292	16	16	81	11	14	6.5
	Water squeezed out of bryophytes growing on limestone	202	194	202	7	11	57	7	7	6.3
	River water	not determined	226	212	7	24	51	12	15	7.9
	Atmospheric snow	4.3	56	16	13	8	5	none	12	6.2
				Parkent River						
7 Aug. 1968	Water squeezed out of algae	not determined	not determined	not deter.	297	164	156	39	20	5.1
22 Aug. 1968	"	"	528	220	11	201	56	22	77	6.7
	The same	"	632	300	22	58	96	17	32	6.3
	River water from place where algae were taken	"	168	156	8	23	24	22	6	8.2
13 July 1969	Rain water	:	48	13	1	28	8	1	7	6.0

In the springtime, when the growth of microorganisms is suppressed by low temperatures, powdery carbonates -- isolated cells of microorganisms remain on conglomerate alluvium after the water drops. In the summertime and the beginning of autumn, they grow into large organic masses. When the water in the river drops, the underwater rocks gradually are uncovered and accumulations of algae show up on the dry rocks and fine river earth, in the form of continuous filaments (warp). According to the analytical data, algae appearing right in the sun in the first 5-10 min do not contain carbonates (0.5-0.8% CO_2), but there is a great amount of calcium in them (57-156 mg/l). In proportion to drying of the suspensions and mineralization of the organic matter, their color changes from brown-green to brownish-pale yellow and then to pale yellow-gray. The amount of carbonate CO_2 increases accordingly: from 5-7% in the first hours of the test to 28% and more after a day.

It is seen under the microscope that small, white calcite /34
crystals appear in the dying cells, initially occupying one fourth of the cell space, and then half of it. After a day, calcite (Figure, stage 3), containing 28% carbonate CO_2, formed from the carbonate-free algae bloom (stage 1). For detritus with colliform carbonate crusts, taken here from the modern alluvium-colluvium stratum, the temperature curve (stage 4) proved to be almost the same as in stage 3 -- it contained 30.8% carbonate CO_2. This is evidence of genetic similarity of the algae bloom on the rocks and the carbonate "beards" on the lower surfaces of the detritus in the alluvium-colluvium, as well as soil, strata.

Of course, the carbonate formation mechanisms in colliform crusts and algae cells differ somewhat. The bloom is formed in the algae cells annually, after the river waters drop and, remaining unattached in the bottom land, is carried off by the wind or mixed with the fine earth.



Thermograms characterizing stages of carbonate formation during drying out of algae deposited from the Parkent river waters (western Tien-Shan): 1. Fresh growths, just removed from the water; 2-3. the same algae after drying in the sun for 3 hr (many organic ion oxide compounds) and 1 day (appearance of calcium carbonate with organic matter and goethite), respectively; 4. calcium carbonate "beards" on the lower surfaces of alluvial detritus (for comparison).

Deposits on the lower surfaces of the detritus are formed annually also, but they remain in place and thicken from year to year. In the spring and summer, when optimum conditions for growth of algae and bacteria are created, large-grain carbonate material most likely is formed intensively. In the wintertime, these processes are slowed down and a fine clay-carbonate sediment is deposited. In this manner, a multi-layer abundance of carbonate "beards" is formed on the lower side of the detritus.

Algae and bacteria, scattered throughout the soil stratum, form not only concentrated, but scattered forms of carbonates. Since the microorganisms absorb other elements (Si, Fe, Mn) besides calcium, the carbonate new growths, even being the smallest elementary particles, are very solid. The dimensions of such particles in the soil also are determined by the sizes of the microorganism cells, which are 7-12 μm, which approximately corresponds to the fractions which are the most enriched in carbonates.

As a rule, carbonates are encountered in soils and alluvium, in the form of solid films and crusts, enveloping mineral grains, which are predominantly feldspars. The appearance of these forms is dependent on the activities of microscopic creatures, and not on deposition of carbonates from water solutions.

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